AN ATTEMPT TO RECORD INTERNAL TREE-TRUNK PRESSURES

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The terms "internal pressure," "root pressure," "exudating pressure," have become familiar to plant physiologists. Chase[1] gives an excellent historical review of the literature and no further citations will be made in this paper.

Most, if not all, workers dealing with gas pressures in plants have attempted to measure such forces by employing water- or mercury-filled manometers. Manual readings have been taken at irregular intervals, and very few automatic timing devices have been used or continuous records obtained. The writer recognized the need of a more elaborate investigation of internal pressures when engaged in a study of pruning paints and fungicides. Trunk cavities had been made in a manner acceptable to professional tree surgeons, but instead of being filled with concrete or some other material they had been covered with heavy plate glass cut to the correct size. Less elaborate ones had been made by drilling holes in the tree trunk and inserting the proper-size watch-glass. Without exception the glasses were either broken or were forcibly ejected from their anchorage in the matrix near the bark edge. An examination showed that they were literally "blown out"—usually within twenty-four hours after installation.

It was felt that pressure measurements would furnish the information needed to devise more substantial anchorages and covers more suitable than glass. Water-filled manometers were attached either to the trunk through a bored hole, or directly to the cavity through a vent tube. A record of the internal pressure—back of a glass-front cavity—as shown by a water-filled manometer follows:

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[1] Chase, W. W. The composition, quantity, and physiological significance of gases in tree stems. Univ. Minn. Agr. Exp. Sta., Tech. Bull. 99:1-51. 1934.

Sept. 24, 1932	Partly cloudy
5:00 P.M.	17 mm. plus.
Sept. 25	Cloudy
11:00 A.M.	5 mm. minus
Noon	0 mm.
1:00 P.M.	0 mm.
2:00 P.M.	1 mm. plus
Sept. 27	Cloudy—rain at noon
9:30 A.M.	4 mm. minus
10:00 A.M.	20 mm. minus
Sept. 28	Clear
11:00 A.M.	12 mm. plus
Noon	16 mm. plus
3:00 P.M.	18 mm. plus
5:00 P.M.	18 mm. plus
Sept. 29	Clear
10:30 A.M.	12 mm. plus
3:30 P.M.	13 mm. plus
5:00 P.M.	13 mm. plus
Sept. 30	Dull—some sun
Noon	12 mm. plus
1:00 P.M.	11 mm. plus
4:30 P.M.	9 mm. plus
Oct. 1	Clear
11:30 A.M.	14 mm. plus
Oct. 3	Clear
11:30 A.M.	11 mm. plus
2:00 P.M.	13 mm. plus
5:00 P.M.	13 mm. plus

The above record simply shows that on cool cloudy days no positive pressures are set up; on the contrary, minus pressures are obtained. On bright sunny days readings are as high as 18 mm. and on partly dull days the pressures are proportionally lower. The record also shows that manual readings, if not carefully taken at hourly intervals during the day and night, will not indicate the trend or rhythm of the phenomenon should they occur. Realizing the need for a continuous automatic record of internal pressure, the writer began to design and construct an instrument for the purpose. A water-filled manometer was fitted into a special case in which a self-recording thermograph had been installed. One arm of the manometer was connected to a bore hole in a tree by a length of rubber hose. The open arm supported a float resting on the water column which actuated a counterbalanced pen arm. The record of the internal pressure, along with the air temperature, was inscribed by the pen directly on the thermograph drum. When attaching the instrument to a sound tree trunk, a taper-threaded brass nipple was turned into a drilled hole 13 mm. in diameter and about 140 mm. deep and usually within two meters of the ground line. If such a hole is drilled radially toward the center of the trunk, some parts of the sapwood will be sealed off by the nipple. In actual practice it is very difficult to determine exactly what layers have been tapped. In the course of several years some hundred or more manometers have been attached to trees—some in sapwood, some in heartwood and many tapped portions of each—and none have shown a characteristic difference.

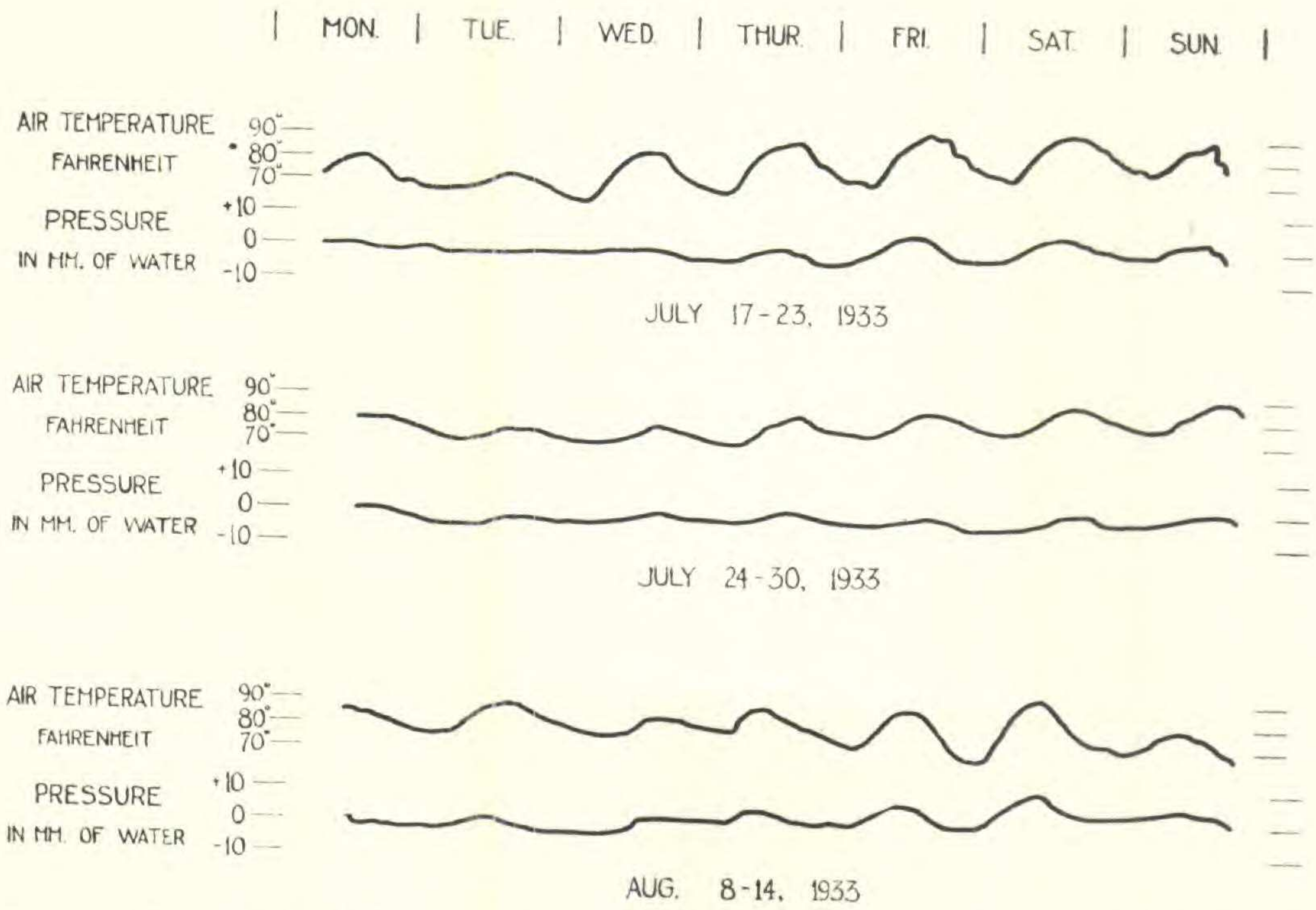

Fig. 1. Record of of internal pressure of *Quercus macrocarpa* for three typical weeks.

The graph (fig. 1) is from the record of three typical weeks, made while the instrument was attached to a Bur Oak (*Quercus macrocarpa.* Michx.). The threaded brass nipple connecting the instrument to the tree tapped both the sapwood and heartwood about one meter above the ground line. The instrument was in operation in this position for seventy weeks. The internal pressure is shown to be influenced only by changes in the volume of the confined air in the manometer and rubber tube connected with the bore hole in the tree trunk. Every fluctuation of the thermograph is duplicated by that of the internal pressure pen. For most of the year, these two records traced on the one chart appear to have been made by two pens permanently linked together. The instrument was at all times protected from the sun by a small shed built around the trunk of the tree, and only the rubber tube projected from a dust-proof metal case. The instrument was not, however, compensated for temperature changes and is therefore subject to the same criticism as any other work in which manometers were used in a similar manner.

After seventy weeks the instrument was disconnected from the trees and "connected" to a mass of ordinary glazing putty. The brass nipple was simply imbedded in the mass of putty and the charts obtained could not be distinguished from those which were produced while attached to the tree. If the tree trunks had ever been under pressures different from those outside the tree, the lag in the establishment of equilibrium between a rising or falling barometric pressure and the pressure within the tree should have been recorded. The records show no lag for any season of the year. During stormy periods, barometric pressures may fluctuate one-half inch or more very quickly, yet there is no evidence that trees are under stress even during that time.

Since trees are apparently never under pressure it was believed that if the barometric conditions of stormy periods could be simulated, perhaps the "lag" in the re-establishment of equilibrium could be measured. It would be nearly impossible to place a mature tree in a chamber capable of pressure or vacuum, but it might be possible to place a tree trunk under pressure by pumping through a bore hole, or partially evacuating the trunk, regardless of atmospheric conditions. A rapidly falling barometer should leave a tree trunk under pressure; while a rising barometer should compress the gas within the bole.

A portable vacuum-pressure unit was constructed which could be used in the field on mature trees. As a compressor the pump was capable of maintaining a pressure of forty pounds per square inch and could handle approximately three cubic feet of air per minute as a vacuum pump. The power source at first was a one-half horse-power air-cooled gasoline engine; later a six volt one-half H.P. electric motor driven by a storage battery. The suction line from the pump passed through two graduated gallon bottles; the second bottle was filled with water which passed over into the bottle nearest the pump. This served as a visual check on the pump performance and permitted a volumetric calculation of the air withdrawn from the tree trunk. In the field the unit was coupled to the tree through the same brass nipple used on the internal-pressure instrument, and water- or mercury-filled manometers were attached in the same manner.

Usually a manometer was placed about one meter below the point of evacuation and from four to six more were placed above this at intervals of one meter. When the pump was started and evacuation begun—at some point near the ground —the effect was almost immediately transmitted to the uppermost manometers. Mercury manometers of sufficient length to record the negative pressures obtained at various levels were not used because of the difficulty of installation and the care needed to avoid breakage. It was found, for instance, that the entire experiment had to be set up in a very short time —usually less than four hours—that bore holes became plugged if made too far in advance. Rarely, for the same reason, could the experiment be duplicated. Very short water-filled manometers were used and the air bubbles carried over furnished evidence of negative pressures within the tree trunk. Accurate timing in starting the pump and careful reading of the pressures became physically impossible—so rapid is the re-establishment of atmospheric pressure within a tree. For instance, after continued evacuation, about ninety seconds were required for the lowest manometer to show zero pressure in a Spanish Oak (*Quercus rubra* L.) seven meters high.

SUMMARY

The need of a better instrument for recording internal pressures was recognized. An automatic instrument of the ''dash-pot'' type was constructed.

The records obtained, either from back of glass-fronted cavities or from bore holes in sound tree trunks, showed clearly that so-called "internal pressures" were due to temperature changes within the instrument.

When a mass of putty replaced the tree trunk identical records were obtained.

Internal pressures—if they exist—cannot be recorded with either manometers or the instrument described. The fluctuating barometric pressures of stormy periods were simulated by applying pressure or suction forces to a tree trunk. With the equipment in use, it was found that suction forces were more easily obtained. Positive pressures are more difficult to observe.

Equilibrium, following evacuation, is so quickly re-established that accurate measurements could not be taken.

It became physically impossible to read manometers placed one meter apart from top to bottom of a mature tree.

The "lag" in the establishment of equilibrium is shown to be about ninety seconds for a certain Spanish Oak.

From these experiments it appears that "internal pressure" differing from atmospheric pressure does not occur in normal sound trees.

Explanation of Plate

PLATE 37

Instrument for recording internal tree-trunk pressures. See explanation in text.